Fall 9-1-2021

PHSX 343.01: Modern Physics

Andrew S. Ware
University of Montana, Missoula, andrew.ware@umontana.edu

Physics 343: Modern Physics Fall 2021

Course Information

- Instructor Name: Andrew Ware
- Office: CHCB 130
- Email: andrew.ware@umontana.edu
- Lectures: MWF 2:00 – 2:50 pm in CHCB 231
- Text: *Modern Physics,* Krane 4th Edition (required)
- Office Hours: M 11 am – 12 pm, T 9 – 10 am, W 1 – 2 pm & F 10 – 11 am & by appointment
- Website: umonline.umt.edu

Overview

The goal of this class is an introduction to the physics revolutions of the twentieth century, especially Einstein's special relativity and quantum physics. We will discuss the experimental evidence that arose which classical physics could not explain and the development of relativity and quantum physics. We will then explore these two theories and their application in Atomic, Statistical, Nuclear, and Particle Physics, and if time permits, Solid-State, Molecular, and Cosmology.

Homework

I'll assign reading, which is **strongly** recommended to be read **before** you come to class. There will be weekly homework. You are welcome to work together on the homework but everyone should turn in their own work. Please do not search the internet for answers. Work together, ask me questions, and make sure you understand the physics behind each problem. This will help you immensely in this course.

Exams

There will be three midterms and one comprehensive final. The first midterm will be around October 4, the second midterm around November 5, and the third around December 3. The final for this course will be from 1:10-3:10 pm on Tuesday, December 14. All exams will be closed book, closed notes, with one equation card allowed.

Grading

Homework	25%
Midterms	45% (15% each)
Final exam	30%

Learning Objectives

After completing this course, you should:

Special Relativity

- Understand the experimental observations that support Special Relativity
- Understand the postulates of Special Relativity and their consequences
- Be able to describe and analyze length contraction and time dilation
- Be able to perform Lorentz transformations
- Understand the conservation of relativistic energy and momentum

Waves and Particles

- Understand the experiments that indicate the particle-like properties of EM radiation
- Be able to calculate conservation of energy and momentum in collisions with photons
- Understand wave-like properties of elementary particles and De Broglie's hypothesis
- Understand the Heisenberg Uncertainty Principle and its consequences

Schrödinger's Equation

- Recognize and analyze Schrödinger's equation
- Understand the meaning of a particle's wave function
- Analyze the wave functions for simple potentials

Quantum Models of an Atom

- Understand the successes and limitations of the Rutherford-Bohr model of an atom
- Understand line spectra and what they tell us about energy levels in an atom
- Be able to analyze the wave function of a hydrogen atom
- Be able to describe the Pauli exclusion principle and how it relates to the periodic table

Quantum Statistics

- Understand the impact of quantum theory on statistical physics
- Understand the difference between fermions and bosons
- Be able to describe Fermi-Dirac and Bose-Einstein statistics

Nuclear Physics

- Understand the basic structure of the nucleus
- Be able to determine nuclear masses and binding energies
- Understand radioactive nuclear decay
- Understand the basics of nuclear fission and fusion

Elementary Particles

- Understand the basic constituents of the Standard Model
- Be able to describe the four fundamental forces in the Universe
- Understand energy and momentum conservation in particle reactions

There will be other learning objectives depending on which of the optional topics we choose to cover.

Course Expectations

This is an upper division course intended for physics majors. The expectations are therefore appropriate for advanced undergraduate students who are familiar with the concepts of personal responsibility, accountability, and academic honesty. I encourage working together on homework and asking me for assistance, but the homework turned in must be the original work of each student. Please do not simply copy answers from other students or from solutions on the internet.

Class Topics

Preliminaries

- Why do we call this modern physics?
- Experimental observations that cannot be explained by classical physics

Special Relativity

- Postulates of Special Relativity and their consequences
- Lorentz transformation
- Relativistic energy and momentum conservation

Photons and EM Radiation

- Photoelectric effect
- Blackbody radiation
- Compton scattering

Particles as Waves

- De Broglie hypothesis
- Heisenberg Uncertainty Principle
- Wave Packets

Schrödinger Equation

- Applications of the Schrödinger Equation
- Confining particles in a box in 1-D
- Simple Harmonic Oscillator

Simple Quantum Atomic Models

- Rutherford-Bohr model of an atom
- Franck-Hertz experiment
- Angular momentum, orbital and intrinsic
- Hydrogen atom wave functions

Advanced Quantum Atomic Models

- Pauli Exclusion Principle
- Multi-electron atomic models
- Addition of angular momenta

Quantum Statistics

- Classical and quantum statistics
- Density of States
- Quantum statistics: Fermi-Dirac and Bose-Einstein

Nuclear Physics

- Nuclear shape, mass and binding energy
- Radioactive nuclear decay
- Nuclear fusion and fission

Elementary Particles

- The Standard Model
- Relativistic energy and momentum conservation in particle reactions

Optional Topics (to be decided on a later date):

Solid State / Molecular Physics / Cosmology

Course Guidelines and Policies

Student Conduct Code

The Student Conduct Code at the University of Montana embodies and promotes honesty, integrity, accountability, rights, and responsibilities associated with constructive citizenship in our academic community. This Code describes expected standards of behavior for all students, including academic conduct and general conduct, and it outlines students' rights, responsibilities, and the campus processes for adjudicating alleged violations. [Full student conduct code: http://www.umt.edu/vpsa/policies/student_conduct.php](http://www.umt.edu/vpsa/policies/student_conduct.php)

Course Withdrawal

Students may use Cyberbear to drop courses through the first 15 instructional days of the semester. Beginning the 16th instructional day of the semester through the 45th instructional day, students use paper forms to drop, add and make changes of section, grading option or credit. PHSX 343 can only be taken for a traditional letter grade.

Accessibility Statement

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and the Office for Disability Equity (ODE). If you anticipate or experience barriers based on disability, please contact the ODE at: (406) 243-2243, ode@umontana.edu, or visit www.umt.edu/disability for more information. Retroactive accommodation requests will not be honored, so please, do not delay. As your instructor, I will work with you and the ODE to implement an effective accommodation, and you are welcome to contact me privately if you wish.

[This course can be taken for a traditional letter-grade only]